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U. S. DEPARTMENT OF AGRICULTURE.
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REPORT

ON

ROAD-MAKING MATERIALS

IN

ARKANSAS.

BY

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF ROAD INQUIRY,
Washington, D. C., March 5, 1894.

SIR: I have the honor to transmit herewith a report on "Road-making materials in Arkansas," prepared by John C. Branner, State geologist. This report was received in response to a circular of inquiry recently sent out by this office, and, as it contains much valuable information, I respectfully recommend its publication by the Department.

Very respectfully,

ROY STONE,
Special Agent and Engineer in Charge.

Hon. J. STERLING MORTON,
Secretary.

ROAD-MAKING MATERIALS IN ARKANSAS.

INTRODUCTION.

The quagmires, ruts, and wrecked wagons that mark our common highways, the reckless waste of the old road system, and the social and commercial isolation that such roads impose upon our people—and especially upon our farmers—during a large part of the winter and spring months must sooner or later convince us that bad roads cost more than good ones. It is not my object, however, to point out the importance of good roads, but simply to call attention to the materials that should be avoided and the materials that should be used when we come to the actual work of road construction. It is also assumed that whenever road-building is taken up seriously properly informed road engineers will have the laying out of the routes and the determination of the details of grades, curves, drainage, cross section, and methods of construction; for unless these details be looked after by those whose business it is to know about and attend to them, no attempt at road-building is likely to be satisfactory or more than half successful.

DISTRIBUTION OF ROAD-MAKING MATERIALS.

The rocks of the State are the State's road-making materials. In some places these rocks lie in their original unbroken beds; in others they are more or less shattered or broken up into talus or gravels, or they have been rolled in the beds of streams and worn into more or less rounded pebbles. But the gravels and pebbles are derived directly from the beds of hard rocks, and therefore have the same general distribution as the strata from which they are derived. The distribution of road-making materials, therefore, depends upon the distribution of the various kinds of rocks, and this depends upon the geology of the State, so that a map showing in detail the distribution of the various kinds of road-making materials would to a certain extent be a geological map.

IMPORTANCE OF SELECTING PROPER MATERIALS.

The road-builder often has to make his roads of whatever he finds at hand, but it often happens that there are several kinds of rock equally convenient, and that he can use one just as well as the other. It is of great importance in such cases that he should know which to

choose; for, as I shall point out, some rocks are altogether unfit for such use, and it is just as important to avoid poor materials as it is to use good ones.

It is intended to speak in this paper, however, only of the materials adapted to making the surface or top-dressing, or "metal," as it is often called, of common roads or turnpikes. Many elements, of course, go to make up a good road, but even with the proper drainage, cross section, foundation, and grade, without a proper surface the road must always be a poor one, besides being expensive to maintain. When the Telford system is used almost any hard rock will answer for the bed-rock of the roadway, but only a few kinds of rock are fit to be used as dressing or road material.

It is proposed, therefore, to point out the advantages of the materials of the State that might be utilized for such purposes, and to call attention to other materials that have been or are liable to be used, but which are judged to be objectionable.

INFERIOR MATERIALS.

For top-dressing of turnpikes or road metal any and all materials that grind up quickly under traffic, forming dust in dry weather or mud in wet weather, must be regarded as objectionable. Such materials have certain advantages for first construction in being more easily prepared, and there is therefore so much more reason for guarding against them. Materials to be avoided for such purposes are, (1) the argillaceous or clay shales, (2) limestones, (3) syenites or "granites," (4) clean sandstone.

THE ARGILLACEOUS OR CLAY SHALES.

The term "shale" is unfortunately not in common use among the people; what geologists call "shale" is often known as "slate" or as "soapstone." The rock is made of clay and hardened; when the clay is pure the rock is known as "argillaceous shale," and when it contains considerable sand it is known as "arenaceous" or "sandy shale." These shales vary somewhat in color; some of them are very black, others are gray, and others are of a reddish color.

For road-building purposes the shales may be divided into two classes—clay shales and sandy shales. The clay shales are entirely unfit for such purposes; the sandy shales are the only ones that should be used for top-dressing. The reason for this is that sooner or later the rocks are crushed and ground up, and that which is made of clay only forms a fine dust when dry, and a pasty, sticky mud when wet. The arenaceous or sandy shales, on the other hand, contain so much grit that they usually pack hard and make a firm roadbed.

The argillaceous shales are not confined to any particular geologic horizon, but may occur with the rocks of any age from the Silurian to

the Tertiary. In the northern part of the State the formation that I have called the Eureka shale is a black or green clay shale. In and south of the Boston Mountains and throughout the Coal Measures area of the State such shales are common, and they also abound in the Silurian area about Hot Springs, and between Hot Springs and Dallas, Polk County, though they by no means form the only or even the greatest part of the rocks of the area mentioned.

LIMESTONES.

Limestone was formerly regarded as one of the best rocks for top-dressing, and it has been exclusively used for such purposes; it has, however, proved very unsatisfactory in the long run, and in many parts of the country the limestone macadamized roads are being taken up and reconstructed of more satisfactory materials. The rock wears easily into an impalpable powder when dry, and forms a sticky paste when wet. Hard limestone makes an excellent roadbed, but it should never be used for surface-dressing. There is a temptation to use limestones for such purposes, because they are easily broken and pack readily on account of their friability; but they wear out with equal readiness, and soon require repairing. The limestones of the State are most abundant in the region north of the Boston Mountains and west of the St. Louis, Iron Mountain, and Southern Railway. There are a few patches of limestone in the ravines heading on the south side of the Boston Mountains and in Garland and Montgomery counties, and some in Clark, Hempstead, Sevier, and Little River counties. (The limestone areas of the State are shown in detail in the maps accompanying Vol. IV of the State geologist's report for 1890, and in that of Vol. II of his report for 1888.) The soft chalky limestones found in Hempstead and Little River counties are especially objectionable for roadmaking.

SYENITES OR "GRANITES."

It has been inferred that because the Little Rock syenite makes good paving blocks and excellent building stone it must make good surface metal when crushed. This, however, is not altogether true. About 80 per cent of the Little Rock syenite is feldspar; when this feldspar decays or when it is finely powdered it forms clay or kaolin. Now, everyone knows that clay should not be used as a top-dressing for roads, for when dry it forms a fine dust, and when wet it forms mud, both of which are objectionable, both on their own accounts and because they mark the beginning of the destruction of the roadway. While, therefore, syenite may make a good dressing for a short time, it must of necessity soon break down into objectionable clay. It is a good rock, however, for roadbeds. The area of feldspathic rocks in the State covers about 13 square miles altogether. They are confined to Pulaski, Saline, and Hot Spring counties, with a few small dikes in

Garland, Montgomery, and a few other counties. (The areas of igneous rocks in the State are given in detail in the maps of Vol. II of the annual report of the State geologist for 1890.)

SANDSTONES.

As a rule, sandstone is not a good road-making rock, but if road-builders will observe the behavior of sandstones of different varieties they will find that some of them make fairly good roadbeds while others will not. This difference is due to the absence or presence of a binding material, and no more specific directions can be suggested than that clean sandstone containing no binding materials as lime, clay, or iron, should not be used for surface metals.

SUPERIOR MATERIALS.

What kind of rock makes the best road metal? Road engineers generally seek the hardest rock they can find, and the principle is, generally, but not always, a correct one. The object to be sought is a hard, smooth road surface that will not grind or cut readily under wheels, so as to make dust or mud. But one of our hardest Arkansas rocks, the so-called granite, is not as good for such purposes as the softer argillaceous shales, because the feldspar which makes the great bulk of the granite soon breaks down into kaolin—one of the stickiest kinds of mud. In the main, however, the method of seeking the hardest rock is a correct one. In north Arkansas, for example, there are four great classes of rocks—the limestones, sandstones, shales, and cherts. Of these the chert (commonly known as flint) is far the hardest and the best for roadmaking.

It is sometimes said that all rocks harden when exposed to weather. This is far from being true of all rocks, though it is true of some of them. Syenite, for example, decomposes when exposed, as do many other rocks which contain soluble constituents.

It should, moreover, never be forgotten by those who undertake to make good roads that the arrangement of the materials is of as much importance as the materials themselves. An authority on this subject (Clemens Herschel in "Pavements and Roads," New York, 1890, p. 322) covers the case exactly when he says that—

> A common gravel sieve often constitutes the principal instrument whose judicious use will make a good road out of a miserable string of ruts and cobbly elevations. It would be only necessary to sift out and separate the soil under the road to a sufficient depth into cobbles, coarse gravel, fine gravel, and sand; then replace them in the order named and with the proper thickness of layers each; wet down and roll, and the result will be a good road.

The materials best adapted for road-making, and having anything like a wide distribution in Arkansas, are: (1) Arenaceous, or sandy

shales; (2) chert, or "flint rock;" (3) novaculite; (4) gravels. These useful materials belong to different geologic formations and are to be looked for only within the areas covered by the formations to which they are confined, or where such materials have been carried by streams into adjacent areas.

ARENACEOUS OR SANDY SHALES.

The arenaceous shales abound in the lower coal measures of the State in the region south of the north face of the Boston Mountains, north of the Fouche and Petit Jean Mountains, and west of the St. Louis, Iron Mountain, and Southern Railway. This region contains sandstones and clay shales as well as the sandy shales, but, as a rule, the sandy shales are very widespread through it. One needs to guard against the clay shales in this region, for they are about as abundant as the sandy shales and the two often grade into each other imperceptibly. The difference between clay shale and sandy shale is that the former is comparatively free from sand or grit, while the latter is a mixture of sand with a certain amount of clay. They can be readily distinguished by cutting with a knife, which will cut clay shale as readily and smoothly as if it were a piece of soap or stearin, but when a sandy shale is cut the knife-blade catches and grates disagreeably upon the sand grains.

In some of the counties within the coal measures sandy shales predominate, while in others the shales are chiefly argillaceous. In Cleburne County, for example, the sandy shales cover a large part of the uplands of the county, and good road-building materials are abundant and convenient almost all over the county. These shales are often more or less micaceous, and for this reason they have been regarded as gold and silver bearing, and some prospecting has been done upon them. It is hardly necessary to say that these sandstones and shales contain neither gold nor silver. If properly utilized, however, they may yet prove of great value to the people of that county as road-making material. These shales generally occur interbedded with sandstones. In the process of weathering the shales break down, first leaving the sandstones as the topographic prominences, forming sharp ridges or capping flat-topped mountains or hills. In regions where the rocks are horizontally bedded the shales may therefore be looked for below the ledges of sandstone, but in regions in which the rocks have been folded the sandstones will be found to form the crests of ridges, while the shales will be found in the valleys. Some of the sandy shales contain a considerable percentage of lime or of iron, and either of these substances acts as a cement and makes a hard smooth roadway. In order to prepare this material for top dressing it has to be quarried out and crushed. It is comparatively soft, however, and not nearly so hard to crush as syenite or sandstone.

CHERT OR "FLINT ROCK."

Chert or flint is one of the hardest of rocks; it does not usually occur in considerable quantities in its original beds, but is everywhere mixed with more or less lime, so that beds of pure chert often grade imperceptibly into pure limestones or marbles. The cherts (in place) in this State are confined to the area lying north of the Boston Mountains and west of the Iron Mountain Railway. Not all this area, however, contains chert beds. There are two horizons at which it occurs in large quantities; the first is that of the Boone chert and cherty limestone lying at or near the base of the Carboniferous series of rocks; the second is the great chert beds lying far below the Boone chert, geologically speaking, and exposed in the counties through which the upper White River flows. The Boone chert (in place) begins in Independence County, just west of the Black River, and near Dota post-office, about 5 miles northeast of Sulphur Rock. It forms a belt of ragged edges from 5 to 15 miles wide, crossing the State from this point past Cushman, Mountain View, Marshall, St. Joe, Harrison, and Eureka Springs, and forming the greater part of the surface of Benton County. Without a large map it is impossible to show the precise distribution of this Boone chert through the northern part of the State. Nothing more can be attempted here, therefore, than to call attention to the material and its general distribution. The Boone chert, as a geologic horizon, is made up of both cherts and limestones, and these elements mingle in the formation in various proportions. When the chert is exposed to the weather it decomposes slightly, the lime in it being dissolved out, sometimes leaving the chert spongy. The "ridge roads" through all the chert regions of the State bear witness to the great value of this chert as a road-making material. These roads, though seldom or never repaired, are hard, compact, dry, and free from mud and dust all the year round. The gravelly roads on the hills about Eureka Springs are all of this Boone chert. The best roads in Benton, Carroll, Boone, Marion, and Searcy counties are on this same formation. All through these chert regions the beds of the streams are filled in places to a depth of 15 feet with the accumulated small fragments of chert, most of which is in a suitable condition for immediate use for road-building.

The chert beds that occur in the Silurian rock of north Arkansas are geologically much lower than the Boone chert, and lie to the north of the Boone chert area. They crop out along the stream bluffs through Randolph, Sharp, Fulton, Izard, and Baxter counties, and large quantities of the broken fragments accumulate in the beds of streams where they are often in excellent condition for road-metal.

In connection with the subject of chert it may be well to call attention to the extensive and increasing use of this material for road-making in southwest Missouri, the refuse from the zinc mines in Jasper County being utilized for such purposes. (The area of the State covered by

the Boone chert is shown in detail on the maps in Vol. IV of the State geologist's report for 1890, and on that with Vol. IV for 1888, and Vol. II for 1891.)

NOVACULITE.

Novaculite is very like chert, both in composition and in its behavior as a road-making material. It occurs, however, only in the hilly region lying south of the Coal Measures, where it forms the Zigzag Mountains about Hot Springs, and the great Ouachita Mountain system south of the Ouachita River extending from Rockport, Hot Spring County, nearly to Indian Territory, west of Dallas, Polk County. It is from this series of rocks that the famous Arkansas whetstones come.

The novaculite is usually much shattered and fractured as it lies, and being for the most part a brittle rock it may readily be broken when it is not already small enough to be used without crushing. Like the chert, it accumulates in vast quantities in the beds of streams and in narrow valleys, and it is from these local accumulations that the material can be had most conveniently for road-making. (The novaculite area of the State is given in detail on the maps accompanying Vol. III of the State geologist's report for 1890.)

THE GRAVELS.

Siliceous gravels have always been regarded as one of the best kinds of road-making materials. They have this considerable advantage over prepared macadam that they require no crushing, and are therefore cheaper, while they have been partially sorted by the waters which transported them to where they are found. When macadam costs from $5,000 to $7,500 per mile, gravel costs from $3,000 to $5,000 per mile. (Pavements and Roads, p. 387.) In many of the Northern States the gravel beds of the glacial drift have furnished excellent road-making materials for entire States. In Arkansas there is no glacial drift, properly speaking, but there are extensive and widespread beds of gravel that are equally good. These gravel beds occur at various places along the immediate valley of the Arkansas River from Fort Smith to Pine Bluff. They are often at a considerable elevation above the present river (at Dublin, Logan County, they are 160 feet; at Little Rock they rise to a height of 140 feet above the river), but they never reach the highest hills. The gravels found along the river are generally mixed with more or less clay, but they may be looked for washed clean of such clay in the streams that cut across the gravel beds, while some cheap method of washing and screening the gravelly clays will yield large quantities of excellent road metal at Little Rock and in many other parts of the State.

It may prove worth while to seek water-worn gravels in the bed of the Arkansas River at places where the current is swift enough to carry away the clay and sand. When found at such places they can be

dredged, just as sand is now dredged at Little Rock. Gravels are dredged from the Ohio River at Evansville, Ind., for covering the streets and roads in the vicinity of that city. Along the upper course of the Rhine gravels are dredged from that stream and used for making roads. The gravels obtained from the bed of the Arkansas River, however, are open to the objection that they will not pack so readily or so hard as those taken from the land. The reason for this is that there is enough iron associated with the gravel beds on land to cement them when they are packed on the road, while the same material, when found in the bed of the river, is comparatively free from the iron and clay, and incapable, therefore, of packing promptly and firmly unless mixed with some other material. The materials in the river have generally been brought so far that the softer fragments have been worn out, and only the very hard ones remain, and these resist crushing and binding. A little sandy clay mixed with such gravel will generally cause it to bind properly.

The material composing the Arkansas gravels referred to under this head is principally chert. It has been washed down the streams flowing into the Arkansas from northwestern Arkansas and southwestern Missouri, which fact accounts for its being found all along the Arkansas valley. Its wide distribution across the valley is due to the meanderings and channel changes of the Arkansas River, and to the ancient floods of that stream.

Beds of gravel having a similar origin occur along the White and Black rivers in north Arkansas and follow the flood plains of those streams. Just north of Sulphur Rock, in Independence County, the water-worn materials cap the hills 250 feet above White River. Farther up the river these gravel deposits occur here and there as isolated patches on the slopes of the inner curves of the larger stream, often high above the present water level.

Through the eastern part of the State the gravels have a wide and even distribution in the geologic sense, though for practical purposes their distribution is local rather than general. Along Crowley's Ridge they are often found concentrated in vast quantities in the beds of streams that flow from the ridge—as, for example, in Little Crow Creek, near Madison, St. Francis County, where they are convenient to railway transportation, and offer abundant and excellent material for road-building through the eastern part of the State, where such material is scarce except in these favored localities along Crowley's Ridge.

About Little Rock such gravels are mingled with the sands and clays that cover almost all the ground upon which the city hall is built. In those parts of the State lying southwest of Little Rock, these gravels are of novaculite, and were derived from the region of novaculite lying between Little Rock and Dallas, in Polk County. Along what was once the old shore line upon which they were worn, and stretching from Little Rock past Benton, Malvern, Arkadelphia, Murfreesboro, Nashville, Center Point, and Locksburg to Ultima Thule, these gravels form

extensive beds, in places 20 feet or more in thickness, while to the south of this line they become gradually finer and less abundant until in the extreme southern part of the State they occur only in patches and the individual pebbles are usually of small size. As in other cases, they are often concentrated along small streams and in narrow valleys. About Nashville and Center Point, in Howard County, gravels of this type are widely distributed, making good natural roads over much of the higher ground of that and the adjoining counties.

In some cases gravel is better than crushed rock, in others the reverse is true; but what this difference is will depend upon the characters of the two kinds of rock used. Gravel is not fit to be used unless it is sorted or mixed with other binding materials and rolled with clay so as to insure its packing hard and firm. Loose, smooth gravels that slip upon each other, and allow the wheels to sink in the roadway, should never be used in that condition.

ABUNDANCE OF ROAD MATERIAL IN ARKANSAS.

It will be seen that Arkansas is well supplied with good road materials, except in the alluvial bottom lands in the eastern parts of the State, and even there gravel available for such purposes may often be found in the stream beds. The road-making materials of the novaculite region, and of the chert region of the north, are as good as one can reasonably ask for—indeed, they are about as good as materials in their natural condition can be—while the gravels of the central and southwestern parts of the State are excellent and sufficiently abundant. In many parts of the State road-making materials are so good, so abundant, and so widespread, that lack of them can never be an excuse for bad roads.

Usually sandy shales are not to be found in the gravel region of the eastern portion of the State, nor chert or novaculite gravels in the elevated carboniferous area of the western portion of the State.

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